TRANSLATOR'S DECLARATION

I, Isamu TAKAHASHI, c/o. Takahashi & Co., 7th floor, Shinoda Bldg., 10-7, Higashi Kanda 1-chome, Chiyoda-ku, Tokyo 101-0031 JAPAN, do hereby declare that I am the translator of the priority document of Japanese Patent Application No. JP2002-341609 and swear that the following is a true translation to the best of my knowledge and belief.

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[Document Title] Specification

[Title of the Invention]

Semiconductor Laser Chip Unit and Semiconductor Laser Module Using the Same

[What is claimed is]

[Claim 1] A semiconductor laser chip unit comprises: a semiconductor laser chip for outputting a laser beam, a heat sink to which the semiconductor laser chip is die-bonded and on which a concavity is formed in the direction of the laser beam outputted, a collimator lens fixed to the concavity for collimating the laser beam outputted from the semiconductor laser chip; and an electrode pattern formed at the heat sink and electrically connected to the semiconductor laser chip.

[Claim 2] The semiconductor laser chip unit, as claimed in claim 1, wherein the collimator lens is a ball lens, the concavity is a groove or a hole, and the ball lens is fixed in the groove or the hole.

[Claim 3] The semiconductor laser chip unit, as claimed in claim 2, wherein the groove is formed in the heat sink along a traveling direction of the laser beam, and the ball lens is fixed in the groove.

[Claim 4] The semiconductor laser chip unit, as claimed in claim 2, wherein the hole is formed in the heat sink on a way of a traveling direction of the laser beam, and the ball lens is fixed in the hole.

[Claim 5] The semiconductor laser chip unit, as claimed in claim 4, wherein a space is provided to the heat sink along a traveling direction of the laser beam.

[Claim 6] The semiconductor laser chip unit, as claimed in any one of claims 1-5, wherein the semiconductor laser chip is formed of indium phosphorus and the heat sink is formed of aluminum nitride.

[Claim 7] The semiconductor laser chip unit, as claimed in any one of claims 1-6, wherein the semiconductor laser chip outputs a front light and a back light from a front end surface and a back end surface, respectively, and the back light may be used as the laser beam.

[Claim 8] The semiconductor laser chip unit, as clamed in any one of claims 1-7, wherein the electrode pattern is a coplanar line with the ground electrode.

[Claim 9] The semiconductor laser chip unit, as claimed in claim 8, wherein the ground electrodes are formed on a top surface of the heat sink on which a concavity is provided and a bottom surface of the heat sink which is formed at the opposite side of the top surface with the heat sink therebetween, and the ground electrodes of the top and bottom surface are connected through a via hole formed in the heat sink.

[Claim 10] The semiconductor laser chip unit, as claimed in any one of claims 1-9, wherein a film resistor

and a chip capacitor are formed on the heat sink.

[Claim 11] The semiconductor laser module comprises: the semiconductor laser chip unit as claimed in any one of claims 1-10, a wavelength detection means for detecting a wavelength of the laser beam passing through the collimator lens, and a temperature control means for controlling the temperature of the semiconductor laser chip, all of which are incorporated in one package.

[Claim 12] The semiconductor laser module as claimed in claim 11, wherein a driver IC for modulating the semiconductor laser chip is incorporated in the package.

[Claim 13] A semiconductor laser module as claimed in claim 11 or 12, wherein the wavelength detection means divides the laser beam by a beam splitter into a beam passing through the wavelength filter and a beam not passing through the wavelength filter, and each beam is detected in the different optical detectors.

[Claim 14] The semiconductor laser module as claimed in any one of claims 11-13, wherein a wavelength detection means comprises a photodiode and a wavelength filter.

[Claim 15] The semiconductor laser module, as claimed in claim 14, wherein a semiconductor laser module of claim 14 in which the wavelength filter is an etalon filter.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a semiconductor laser chip unit for use in optical fiber communications, and a semiconductor laser module using the semiconductor laser chip unit.

[0002]

[Description of the Related Art]

As the use of the Internet has been explosively widespread, demand for expanding transmission capacity is strongly increased in recent years. Thus, not only an optical transmission using the wavelength of a single semiconductor laser diode, but also it is important to realize wavelength multiplex communications in which a plurality of semiconductor laser diodes are used and a plurality of wavelengths are multiplexed with high density. In this case, since the oscillation wavelength of a semiconductor laser diode fluctuates depending on temperatures (eg., 0.1nm/°C), a technique to keep the temperature of the semiconductor laser diodes constant is known. However, only keeping the temperature of the semiconductor laser diode constant cannot suppress fluctuations of the wavelength caused by the deterioration with time of the semiconductor laser diode.

[0003]

In Patent document 1, for example, there is disclosed a technique to continuously detect the wavelength and to feedback-control the temperature of the semiconductor laser chip so as to keep the wavelength constant. Fig. 7 is a diagram showing a conventional semiconductor laser module disclosed in the Patent document 1. Explanations will be given below with reference to the Figure.

[0004]

A light source for use in the semiconductor laser module is an integrated light source 111 in which a semiconductor laser chip 101 of the distributed feedback type and an optical modulator 102 of the electric field absorption type are monolithically integrated. A front optical output from the integrated light source 111 is optically coupled on an optical fiber 115 through a front collimator lens 112, an optical isolator 113 which blocks a reflected return light from an optical unit on the transmission path, and a convergent lens 114.

[0005]

A back optical output from the integrated light source 111, on the other hand, is made incident on a high reflection film 104 coated on the light receiving surface of a photodiode 103 through a back collimator lens 117.

By setting the reflection rate of the high reflection film 104 to be about 50 to 80%, a laser beam not reflected by the high reflection film 104 is made incident on the photodiode 103. This photodiode 103 serves as an optical output monitor 116.

[0006]

The laser beam reflected at the high reflection film 104 on the surface of the optical output monitor 116 is made incident on a non-reflective film 105 coated on the light receiving surface of a photodiode 106 through a wavelength filter 118, the transmission loss of which has a wavelength dependency. This photodiode 106 serves as a wavelength monitor 119.

[0007]

In this semiconductor laser module, respective optical elements, including the integrated light source 111, the front collimator lens 112, the back collimator lens 117, the optical output monitor 116, the wavelength filter 118 and the wavelength monitor 119, are mounted on a stem 122 on which a temperature detection element 120 is mounted, which stem is disposed on a thermionic cooling element 121. Therefore, respective optical elements are kept at the stable temperature and are fixed in a mechanically stable manner within a hermetic sealing package 123 by soldering or YAG laser welding.

[0008]

In this way, the back optical output from the integrated light source 111 is branched. One of the branched output is detected at the photodiode 103, and the other is passed through the wavelength filter 118 so as to be detected at the photodiode 106. Based on signals from the photodiode 106 reflecting the transmission characteristic of the wavelength filter 118, the oscillation wavelength is controlled by feedback-controlling the temperature of the integrated light source 111 with a use of the temperature detection element 120 and the thermionic cooling element 121.

[0009]

[Patent document 1]

Japanese Patent Application Laid-open No. 2001-313613 (Fig. 1, etc)

[Patent document 2]

Japanese Patent Application Laid-open No. 2001-164970 (Fig. 1, etc)

[0010]

[Problem to be Solved by the Invention]

However, in the technique disclosed in the Patent document 1, the high-frequency characteristic of the semiconductor laser chip 101 cannot be measured without inputting a high-frequency signal with a use of a pin (not

shown) of the hermetic sealing package 123. If the semiconductor laser chip 101 is determined as defective in this measurement stage, the hermetic sealing package 123 and each optical unit must be disposed, or the unit must be replaced spending many work man-hours.

[0011]

In the Patent document 2, there is disclosed a structure in which a semiconductor laser and a coplanar line are provided on a substrate which is mounted on a career. With this structure, the high-frequency characteristic of a semiconductor laser diode can be measured before mounted on the career. However, since it has a structure that the back light from the semiconductor laser is directly received at a photodiode, a precise optical axis adjustment is required between these optical units. Further, when receiving the back light with two photodiodes (the optical output monitor and the wavelength monitor), these two photodiodes must be separately mounted from the semiconductor laser in the direction of the optical axis to widen the irradiation range so that both photodiodes can receive it. In this case, regarding the diffusion of the back light, two photodiodes are separately mounted from the center position on which the power concentrates. Thus, by monitoring the light of circumference area, power for monitoring is difficult to

obtain, and there is a problem that the monitor signal is unstable.

[0012]

[SUMMARY OF THE INVENTION] object of the Invention

It is therefore an object of the present invention to provide a semiconductor laser chip unit which is capable of reducing cost damages even when a semiconductor laser chip is defective or the like and is capable of achieving a wavelength control with high precision, and to provide a semiconductor laser module using the semiconductor laser chip unit.

[0013]

[Scheme for Solving the Problems]

A semiconductor laser chip unit of the present invention comprises: a semiconductor laser chip for outputting a laser beam, a heat sink to which the semiconductor laser chip is die-bonded and on which a concavity is formed in the direction of the laser beam outputted, a collimator lens fixed to the concavity for collimating the laser beam outputted from the semiconductor laser chip; and an electrode pattern formed at the heat sink and electrically connected to the semiconductor laser chip.

[0014]

When a semiconductor laser chip is conducted by

contacting a probe needle and the like on the electrode pattern, the semiconductor laser chip emits light, so it is possible to inspect characteristics of the high frequency signal. And a laser beam outputted from the semiconductor laser chip is collimated by the collimator lens. Thus, the collimated light can be obtained with the semiconductor laser chip by conducting the semiconductor laser chip unit. Therefore, it is possible to inspect whether the semiconductor laser chip is defective, whether positioning of the semiconductor laser chip and the collimator lens is drifted or the like, before the semiconductor laser chip is mounted in the package. It is also possible to control wavelength with high precision, since an outputted collimated light is stable and easy for the inspection Further, the collimated light is obtained by fixing the collimator lens on the concavity of the heat sink, so that a simple and stable configuration can be obtained.

[0015]

A semiconductor laser chip unit described in claim 2 is the semiconductor laser chip unit of claim 1 in which the collimator lens is a ball lens, the concavity is a groove or a hole, and the ball lens is fixed in the groove or the hole. By forming the groove or the hole on the heat sink and fixing the ball lens in the groove or the

hole, positioning of the collimator lens can be easily performed. Since the ball lens is easily fitted in the groove or the hole by its own weight, and there is no particular direction.

[0016]

A semiconductor laser chip unit described in claim 3 is the semiconductor laser chip unit of claim 2 in which the groove is formed in the heat sink along a traveling direction of the laser beam and the ball lens is fixed in the groove. It is possible to prevent a laser beam passing through the ball lens from being interfered by the heat sink.

[0017]

A semiconductor laser chip unit described in claim 4 is the semiconductor laser chip unit of claim 2 in which the hole is formed in the heat sink on the way of a traveling direction of the laser beam, the ball lens is fixed in the hole. The ball lens can move in the groove, but cannot move in the hole. Further, the hole can be made easier than the groove. Accordingly, the ball lens can be fixed with high precision and forming on the heat sink becomes easy.

[0018]

A semiconductor laser chip unit described in claim 5 is the semiconductor laser chip unit of claim 4 in which a

space is provided to the heat sink along a traveling direction of the laser beam which has passed through the ball lens. So, it is possible to prevent the laser beam having passed through the ball lens from being interfered by the heat sink.

[0019]

A semiconductor laser chip unit described in claim 6 is the semiconductor laser chip unit as clamed in any one of claims 1-5 in which the semiconductor laser chip is formed of indium phosphorus and the heat sink is formed of aluminum nitride. Thus, the thermal expansion coefficients of indium and aluminum nitride are close so that the heat stress from the heat sink to the semiconductor laser chip can be suppressed. Further, since aluminum nitride has a low conductive rate, the loss of high frequency can be small.

[0020]

A semiconductor laser chip unit described in claim 7 is the semiconductor laser chip unit as claimed in any one of claims 1-6 in which the semiconductor laser chip outputs a front light and a back light from a front end surface and a back end surface, respectively, and the back light may be used as the laser beam. The back light outputted from the semiconductor laser chip is converted to the collimated light by a collimator lens. When this

collimated light passes through a wavelength filter, the wavelength of the laser beam outputted from the semiconductor laser chip can be detected precisely, since the permeation characteristic of the light with a wavelength filter is changed by a wavelength of the light. Accordingly, a preferable sub unit for a semiconductor laser module which detects the wavelength of the laser beam and feedback-controls the semiconductor laser chip so that the wavelength becomes constant can be obtained.

[0021]

A semiconductor laser chip unit described in claim 8 is the semiconductor laser chip unit as clamed in any one of claims 1-7 in which the electrode pattern is a coplanar line with the ground electrode.

[0022]

A semiconductor laser chip unit described in claim 9 is the semiconductor laser chip unit of claim 8 in which the ground electrodes are formed on a top surface of the heat sink on which a concavity is provided and a bottom surface of the heat sink which is formed at the opposite side of the top surface with the heat sink therebetween, and the ground electrodes of the top and bottom surface are connected through a via hole formed in the heat sink.

[0023]

A semiconductor laser chip unit described in claim

10 is the semiconductor laser chip unit as clamed in any one of claims 1-9 in which a film resistor and a chip capacitor are formed on the heat sink. The film resistor is a thin film resistor, a thick film resistor, and the like.

[0024]

A semiconductor laser module according to the present invention (claim 11) comprises: the semiconductor laser chip unit, a wavelength detection means for detecting a wavelength of the laser beam passing through the collimator lens, and a temperature control means for controlling the temperature of the semiconductor laser chip, all of which are incorporated in one package. By using the semiconductor laser chip unit according to the present invention, it is possible to inspect whether the semiconductor laser chip is defective, whether positioning of the semiconductor laser chip and the collimator lens is drifted or the like, before the semiconductor laser chip is mounted in the package. Therefore, when there is any defective semiconductor laser chip or the like, cost damages can be reduced comparing with a case of inspecting the semiconductor laser chip defection after the semiconductor laser chip is mounted in the package.

[0025]

A semiconductor laser module described in claim 12

is the semiconductor laser module of claim 11 in which a driver IC for modulating the semiconductor laser chip is incorporated in the package. A high-frequency signal is outputted from a driver IC and inputted into a semiconductor laser chip in the same package. Therefore, the transmission path of the high-frequency signal to the semiconductor laser chip can be greatly reduced comparing with a case of disposing the driver IC outside of the package. With this structure, a fine high-frequency signal can be transmitted to the semiconductor laser chip.

[0026]

A semiconductor laser module described in claim 13 is the semiconductor laser module of claim 11 or 12 in which the wavelength detection means divides the laser beam by a beam splitter into a beam passing through the wavelength filter and a beam not passing through the wavelength filter. In the case of detecting the laser beams in the different optical detectors by using the wavelength filter, each optical detector comes close to each other if a beam splitter is not used. Therefore, a light reflected on the side face of the wavelength filter may become a stray light, which is to be made incident on the optical detector. In the present invention, this does not occur since the laser beam is divided by the beam splitter.

[0027]

A semiconductor laser module described in claim 14 is the semiconductor laser module as clamed in any one of claims 11-13 in which a wavelength detection means comprises a photodiode and a wavelength filter.

[0028]

A semiconductor laser module described in claim 15 is the semiconductor laser module of claim 14 in which the wavelength filter is an etalon filter. With the etalon filter, the permeation characteristic of the light is changed by not only a wavelength of the light but also an incident angle of the light. Therefore, by making the laser beam to be a parallel light and making the incident angle against the wavelength filter constant, the wavelength of the laser beam are accurately detected. Further, the etalon filter has a periodical permeation characteristic according to the wavelength, and is capable of shifting the permeation characteristic corresponding to an incident angle. Therefore, one type of etalon filter can work as a wavelength filter for different wavelengths of plural types.

[0029]

[PREFERRED EMBODIMENTS OF THE PRESENT INVENTION]

Fig. 1 shows a first embodiment of a semiconductor laser chip unit according to the present invention, in

which Fig. 1[1] is an overall perspective view, and Fig. 1[2] is a longitudinal sectional view taken along the line I-I in Fig. 1[1]. Explanations will be given below with reference to these Figures.

[0030]

A semiconductor laser chip unit 10 of the present embodiment forms a sub unit (sub module) comprising: a semiconductor laser chip 11 which outputs a front light 12a and a back light 12b from a front end surface 11a and a back end surface 11b, respectively; a heat sink 13 on which the semiconductor laser chip 11 is die-bonded; a ball lens 14 which is fixed in the heat sink 13 so as to convert the back light 12b outputted from the semiconductor laser chip 11 into a collimated light; and electrode patterns 161, 162 which are formed on the heat sink 13 and are electrically connected to the semiconductor laser chip 11.

[0031]

The heat sink 13 is provided with a V-groove 15 formed along a travelling direction of the back light 12b. The V-groove 15 has a V-shaped cross section. In the V-groove 15, the ball lens 14 is fixed at a position against the back end surface 11b of the semiconductor laser chip 11.

[0032]

On the top surface of the heat sink 13, the electrode patterns 161, 162 and a ground electrode 163 for transmitting high-frequency signals and a thin film resistor 17 of 50Ω for the end of the high-frequency signal are formed, and a chip capacitor 18 for preventing the semiconductor laser chip 11 from breakage caused by a surge current of a bias current is soldered. The electrode patterns 161, 162 and the semiconductor laser chip 11 are electrically connected by bonding wires 191, 192, respectively. The chip capacitor 18 and the semiconductor laser chip 11 are electrically connected by the bonding wire 193. It should be noted that the electrode patterns 161, 162 and the ground electrode 163 are, for example, gold plated films with about 1μm to 4μm, and the bonding wires 191 to 193 are, for example, gold wires.

[0033]

The ball lens 14 for collimating the back light 12b is fixed in the V-groove 15 of the heat sink 13 by a UV adhesive or the like. Preferably, the end side in the V-groove 15 is inclined for fixing the ball lens 14 stably. In order to fix the ball lens 14 in the V-groove 15, a low-melting glass, a solder or the like may be used.

[0034]

A coplanar line with the ground electrode 163 is

used for the electrode patterns 161, 162 for high-frequency signals, and they are designed to have the characteristic impedance of the coplanar line of 50Ω. The semiconductor laser chip 11 is die-bonded on the ground electrode surface 163 on the heat sink 13 through a back electrode (not shown). Further, a ground electrode 164 is deposited across the back surface of the heat sink 13. The ground electrode 163 on the top surface of the heat sink 13 and the ground electrode 164 on the back surface are connected each other by a via hole (a through hole, not shown).

[0035]

As the heat sink 13, aluminum nitride is used. A first reason is, since the electric resistance of the aluminum nitride is 10^8 higher than that of silicon, a leakage loss is low when the high-frequency signals propagate the electrode patterns 161, 162. A second reason is, since the thermal expansion coefficient of aluminum nitride is almost the same as that of indium phosphorus which is the material of the semiconductor laser chip 11, it is less prone to a stress caused by a distortion or the like when the temperature fluctuates.

[0036]

A bias current to the semiconductor laser chip 11 is supplied through the chip capacitor 18 and the bonding

wire 193. A high-frequency signal to the semiconductor laser chip 11 is inputted through the electrode pattern 161 and the bonding wire 191 of the coplanar line.

In the present embodiment, since the electrode patterns 161, 162 for high-frequency signals, the thin film resistor 17 for the end, and the ball lens 14 are mounted on the heat sink 13, a characteristic test of the semiconductor laser chip 11 and an inspection of a collimated light of the back light 12b can be performed before the semiconductor laser chip unit 11 is incorporated into a package, so that defective parts can be eliminated before incorporated into a package, and it is possible to obtain the semiconductor laser module with small cost damage.

[0037]

Fig. 2 shows a second embodiment of a semiconductor laser chip unit according to the present invention, in which Fig. 2[1] is an overall perspective view, and Fig. 2[2] is a longitudinal sectional view taken along the line II-II in Fig. 2[1]. Explanations will be given below with reference to these Figures. Same reference numerals are used to denote the same parts as Fig. 1 so that their explanations are omitted.

[0038]

In a semiconductor laser chip unit 20 of the present

their explanations are omitted.

[0044]

A semiconductor laser module 40 of the present embodiment uses the semiconductor laser chip unit 10 of Fig. 1, and has a function of converting a light oscillated from the semiconductor laser chip 11 and transmitting it by an optical fiber 53, as well as monitoring the wavelength using the back light 12b of the semiconductor laser chip 11.

[0045]

A package 41 with a lead comprises a frame 55 formed of ceramic such as alumina, and a base 56 formed of CuW or the like. An electronic cooling element 42 for adjusting the temperature of the semiconductor laser chip 11 is soldered on the base 56, and a metal carrier 47 is soldered thereon. On the top surface of the carrier 47, there are mounted a temperature sensing element 54 for sensing the temperature of the semiconductor laser chip 11, a lens 50, a wavelength filter 49 for monitoring the wavelength of the semiconductor laser chip 11, optical detectors 43, 44 and the like. The heat sink 13 is formed of aluminum nitride having a high thermal conductivity in order to dissipate a heat released from the semiconductor laser chip 11 to the carrier 47 effectively.

[0046]

The wavelength filter 49 may be an etalon filter. Since an etalon filter has a periodical permeation property corresponding to a wavelength and is capable of shifting the permeation property depending on incident angles, one type of etalon filter can work as a wavelength filter for various wavelengths of plural types. Therefore, it has a cost merit comparing with a bandpass filter which needs to be prepared in plural types for covering a broadband. It should be noted that since an etalon filter changes the permeation property depending on incident angles, it can be used by collimating the back light in such a manner that the incident angles are to be the same, as this structure.

[0047]

Next, an operation of the semiconductor laser module 40 will be explained. The semiconductor laser chip 11 emits light by a bias current inputted from an input terminal pin 45. A signal from an input terminal pin 46 is inputted to the semiconductor laser chip 11 through a wiring board 48 for high-frequency signals. Further, a thin film resistor 17 is wired with a bonding wire 192 so as to cause the thin film resistor 17 of 50Ω to be in parallel with the semiconductor laser chip 11, since the resistor is the end of the high-frequency signal. With this structure, a light emitted from the semiconductor

laser chip becomes the one modulated by the high-frequency signal.

[0048]

The modulated front light 12a is converted to be a collimated light by a lens 50, and after passing through an optical isolator 51, condensed by a lens 52 and made incident on the optical fiber 53. On the other hand, the back light 12b of the semiconductor laser chip 11 is converted into a collimated light through the ball lens 14, a part of which is directly detected by an optical detector 43, and the rest is made incident on an optical detector 44 through a wavelength filter 49 such as an etalon filter. By using an output current value of the optical detector 43, constant controlling of the optical output of the semiconductor laser chip 11 is performed. Further, based on an output current value of the optical detector 44, the temperature of the semiconductor laser chip 11 is controlled by the electronic cooling element 42 while monitored by the temperature sensing element 54, to thereby stabilize with high precision the wavelength oscillated by the semiconductor laser chip 11.

[0049]

Fig. 5 is a plan view showing a second embodiment of the semiconductor laser module of the present invention. Explanations will be given below based on Figs. 1 4 and 5.

Same reference numerals are used to denote same parts in Fig. 5 as that in Fig. 4 so that their explanations are omitted.

[0050]

In the first embodiment shown in Fig. 4, a high-frequency signal to the semiconductor laser chip 11 is input from the input terminal pin 46, passes through the wiring board 48 via the bonding wire, and further passes through the electrode pattern 161 on the heat sink 13 and the bonding wire 191, to thereby reach the semiconductor laser chip 11. Thus, the high-frequency signal is prone to be distorted by impedance mismatching since it passes through a long transmission path. So, a driving waveform of the semiconductor laser chip 11 may be affected.

[0051]

In a semiconductor laser module 60 of the present embodiment, a terrace 58 formed of ceramic or the like is formed in a package 41 onto which a driver IC 57 for generating high-frequency signals is mounted. By mounting the driver IC 57 for modulating a semiconductor laser chip onto the terrace 58 in the close proximity of the semiconductor laser chip 11, a transmission path for high-frequency signals to the semiconductor laser chip 11 can be largely reduced so that the high-frequency signals are transmitted to the semiconductor laser chip 11 in good

condition. That is, by mounting the driver IC 57 in the semiconductor laser module 60, the distance between the driver IC 57 and the semiconductor laser chip 11 can be shorten so that the high-frequency characteristic is improved.

[0052]

Fig. 6 is a plan view showing a third embodiment of the semiconductor laser module according to the present invention. Explanations will be given below based on Figs. 1, 4 and 6. Same reference numerals are used to denote same parts in Fig. 6 as that in Fig. 4 so that their explanations are omitted.

[0053]

In the first embodiment in Fig. 4, the back light 12b of the semiconductor laser chip 11 is divided into a light passing through the wavelength filter 49 and a light not passing through the wavelength filter 49, each of which is detected by the different optical detector 44, 43. Thus, each optical detector 44 and 43 comes close to each other. Therefore, a light reflected on the side face of the wavelength filter 49 may become a stray light, which is to be made incident on the optical detector 43.

[0054]

In a semiconductor laser module 70 of the present embodiment, the back light 12b of the semiconductor laser

chip 11 is branched by a beam splitter 59. One of the branched lights is directly made incident on the optical detector 43, and the other is made incident on the optical detector 44 through the wavelength filter 49. As such, influences of the edge portion of the wavelength filter 49 need not to be considered, so that assembling man-hour can be reduced. On the other hand, the first embodiment shown in Fig. 4 has one piece less components than the present embodiment. Therefore, it has a merit of making the structure simple. Instead of the beam splitter 59, a half mirror may be used.

[0055]

It should be noted that the present invention is of course not limited to the aforementioned embodiments. For example, the heat sink may be formed of another ceramic such as alumina, silicon or the like, instead of aluminum nitride. Further, not only for the back light but also for the front light, a groove or a hole may be formed on the top surface of the heat sink and a collimator lens may be mounted therein, so as to form it as a subunit.

[0056]

[Effects of the Invention]

According to the semiconductor laser chip unit of the present invention, the semiconductor laser chip, the heat sink onto which the semiconductor laser chip is die-

bonded, the collimator lens which is fixed on the heat sink and converts the laser beam output from the semiconductor laser chip into a parallel light which is collimated, and the electrode pattern which is electrically connected to the semiconductor laser chip and fixed on the heat sink, are formed to be a sub unit. With this configuration, a high-frequency characteristic can be inspected by conducting the semiconductor laser chip unit, and also the parallel light can be obtained from the semiconductor laser chip. Therefore, it is possible to inspect whether a semiconductor laser chip is defective, or whether positions of a semiconductor laser chip and a collimator lens are drifted, before the semiconductor laser chip is incorporated into a package. In other words, since inspections can be performed in the state of a sub unit, defective components can be eliminated before being incorporated in a package or the like. Therefore, it is possible to reduce cost damages even when defective components are found. Further, it is possible to cause an output light to be a collimated light which is stable and easy to be inspected in the state of a unit. As such, since the light is processed into a form which is stable and easy to be inspected, wavelength controlling can be realized with high precision. Further, it is possible to obtain a collimated light with such a simple and stable

structure that a collimator lens is fixed in a concavity formed in the heat sink. In addition to the aforementioned effects, unique effects are exhibited in the following cases, respectively.

[0057]

If a groove or a hole is formed in the heat sink and a ball lens is fixed in the groove or the hole, positioning of the collimator lens can be easily performed.

[0058]

If the groove is formed in the heat sink along a travelling direction of the laser beam and the ball lens is fixed in the groove, it is possible to prevent a back light passing through the ball lens from being interfered by the heat sink.

[0059]

If the hole is formed in the heat sink on the way of a travelling direction of the laser beam and the ball lens is fixed in the hole, the ball lens can be fixed with high precision and manufacturing becomes easy.

[0060]

If the hole is formed in the heat sink on the way of a travelling direction of the laser beam, the ball lens is fixed in the hole, and a space is provided to the heat sink along a travelling direction of the laser beam which has passed through the ball lens, it is possible to

prevent the laser beam having passed through the ball lens from being interfered by the heat sink.

[0061]

If the semiconductor laser chip is formed of indium phosphorus and the heat sink is formed of aluminum nitride, a leakage loss and a heat stress become small.

[0062]

If the back light output from the semiconductor laser chip is converted into a parallel light by the collimator lens, the back light is accurately detected so that the semiconductor laser chip can be preferably used in a semiconductor laser module which feedback-controls the semiconductor laser chip.

[0063]

The semiconductor laser module of the present invention uses the semiconductor laser chip unit according to the present invention so that it is possible to inspect whether the semiconductor laser chip is defective, or whether positions of the semiconductor laser chip and the collimator lens are drifted, before the semiconductor laser chip is incorporated into a package. Therefore, even when there is any defective semiconductor laser chip or the like, cost damages can be reduced. Further, since a collimated light can be obtained in the state of a sub unit and the light is processed to be in a form of stable

and easy to be inspected, a wavelength control with high precision can be achieved. In addition to the aforementioned effects, further unique effects will be exhibited in the following case.

[0064]

If a driver IC for converting the semiconductor laser chip is provided in the package, the transmission path for high-frequency signals to the semiconductor laser chip can be greatly reduced. Therefore, high-frequency signals can be transmitted to the semiconductor laser chip in good condition.

[0065]

If the laser beam is branched using a beam splitter into one passing through the wavelength filter and one not passing through the wavelength filter, it is possible to prevent the reflected light from the edge of the wavelength filter from being incident on an optical detector as a stray light.

[0066]

Since a collimated light can be obtained in the state of a sub unit, an etalon filter can be used as a wavelength filter. In this case, one type of etalon filter works as a wavelength filter for various wavelengths of plural types.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1]

A first embodiment of a semiconductor laser chip unit according to the present invention, in which Fig. 1[1] is an overall perspective view, and Fig. 1[2] is a longitudinal sectional view taken along the line I-I in Fig. 1[1];

[Fig. 2]

A second embodiment of the semiconductor laser chip unit according to the present invention, in which Fig. 2[1] is an overall perspective view, and Fig. 2[2] is a longitudinal sectional view taken along the line II-II in Fig. 2[1];

[Fig. 3]

A third embodiment of the semiconductor laser chip unit according to the present invention, in which Fig. 3[1] is an overall perspective view, and Fig. 3[2] is a longitudinal sectional view taken along the line III-III in Fig. 3[1];

[Fig. 4]

A first embodiment of a semiconductor laser module according to the present invention, in which Fig. 4[1] is a plan view, and Fig. 4[2] is a longitudinal sectional view taken along the line IV-IV in Fig. 4[1];

[Fig. 5]

A plan view showing a second embodiment of the semiconductor laser module according to the present invention;

[Fig. 6]

A plan view showing a third embodiment of the semiconductor laser module according to the present invention;

[Fig. 7]

A diagram showing a conventional semiconductor laser module.

[Description of Symbols]

10 Semiconductor laser chip unit

11a Front end surface

11b Back end surface

12a Front light

12b Back light

11 Semiconductor laser chip

13, 21, 31 Heat sink

14 Ball lens (Collimator lens)

161, 162 Electrode patterns

163, 164 Ground electrode

15 V-groove

22 Hole

32 Space

41 Package

42 Electronic cooling element (Temperature control means)

43 Optical detector (Wavelength detection means)

44 Optical detector

49 Wavelength filter (Wavelength detection means)

54 Temperature sensing element

57 Driver IC

[Document title] Abstract

[Abstract]

[Object]

To reduce the cost damage even when a semiconductor laser chip is defective.

[Scheme]

A semiconductor laser chip unit 10 includes a semiconductor laser chip 11, a heat sink 13 to which the semiconductor laser chip 11 is die-bonded, a ball lens 14 fixed to the heat sink 13 for collimating the back light 12b outputted from the semiconductor laser chip 11; and an electrode pattern 161, 162 formed at the heat sink 13 and electrically connected to the semiconductor laser chip 11. The collimated light can be obtained with the semiconductor laser chip 11 by conducting the semiconductor laser chip unit10. Therefore, it is possible to inspect whether the semiconductor laser chip 11 is defective or the like, before the semiconductor laser chip 11 is mounted in the package.

[Selected Drawings] Fig. 1